

Predicting Students' Academic Achievement in Physics Through Principals' Instructional Leadership, Teachers' Assessment Literacy and Digital Instructional Resources in Secondary Schools: Implications for Mathematics Curriculum

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ABSTRACT

This study examined the extent to which principals' instructional leadership, teachers' assessment literacy and digital instructional resources predicted students' academic achievement in Physics in secondary schools in Enugu State, Nigeria, with implications for Mathematics curriculum. The study adopted a predictive correlational research design. The population comprised 12,329 Senior Secondary School II Physics students in 304 public secondary schools, from which a sample of 391 students was drawn using a multistage sampling procedure. Data were collected using the Students' Version of the Principals' Instructional Leadership Questionnaire (PILQ), Teachers' Assessment Literacy Questionnaire (TALQ), Digital Instructional Resources Questionnaire (DIRQ) and Physics

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Achievement Test (PAT). The reliability coefficients of 0.82, 0.87 and 0.85 were obtained for PILQ, TALQ and DIRQ respectively using Cronbach Alpha, while the reliability coefficient of PAT was 0.89 using Kuder-Richardson 20 (KR-20). Data were analysed using simple and multiple regression analyses, with hypotheses tested at the 0.05 level of significance. The findings showed that principals' instructional leadership significantly predicted students' academic achievement in Physics, accounting for 31.3% of the variance ($R = .560$, $R^2 = .313$, $p < .001$). Teachers' assessment literacy significantly predicted achievement, explaining 43.4% of the variance ($R = .659$, $R^2 = .434$, $p < .001$), while digital instructional resources significantly predicted achievement, accounting for 27.5% of the variance ($R = .524$, $R^2 = .275$, $p < .001$). Jointly, the three predictors had a strong positive predictive relationship with students' achievement and accounted for 67.6% of its variance ($R = .822$, $R^2 = .676$). The joint regression model was statistically significant, $F(3, 387) = 268.645$, $p < .001$. The study concluded that effective instructional leadership, teachers' assessment literacy and purposeful use of digital instructional resources are important conditions associated with students' academic achievement in Physics. The findings further suggest that these factors have implications for the implementation and evaluation of the Mathematics curriculum, particularly in relation to instructional leadership, assessment practices and digital learning environments.

Keyword: Principals' instructional leadership; teachers' assessment literacy; digital instructional resources; students' academic achievement; Physics; Mathematics curriculum.

Introduction

Physics occupies a strategic position in secondary school education because it provides learners with fundamental knowledge of matter, energy, motion, forces, electricity, magnetism and other phenomena that underpin scientific and technological development. Beyond its status as a school subject, Physics contributes to the development of scientific reasoning, quantitative thinking, problem-solving ability and technological literacy, which are increasingly important in economies driven by science and innovation. The Federal Republic of Nigeria (2013) recognizes science and technology as important components of education for national development, while Aina (2013) emphasizes the importance of effective Physics teaching in developing learners'

understanding of scientific principles and their applications. Therefore, the quality of students' achievement in Physics remains an important concern for secondary school education because it reflects, to some extent, the effectiveness of the processes through which scientific knowledge and skills are developed.

Despite the strategic importance of Physics, evidence from students' performance in external examinations suggests that achievement in the subject has remained a concern. The Chief Examiners' Reports of the West African Examinations Council (WAEC) over the four-year period (32-54) consistently reported weaknesses in candidates' performance in important areas of Physics. The reports indicated difficulties in areas such as the application of Physics principles to

unfamiliar situations, interpretation of diagrams and graphs, mathematical calculations, understanding of basic concepts, and the appropriate use of scientific terms and units. These recurring weaknesses suggest that some students may be experiencing difficulties not only with recalling Physics concepts but also with applying knowledge to solve problems and interpret physical phenomena. The persistence of these challenges across successive examination years provides evidence that students' achievement in Physics warrants continued scholarly attention and calls for closer examination of the factors that may contribute to variations in learning outcomes.

Students' academic achievement in Physics is influenced by a complex interaction of learner, teacher, school and instructional factors. Physics requires students to integrate abstract concepts, mathematical relationships, experimentation, graphical representations and problem-solving processes. Thus, students' success in the subject cannot be attributed solely to their intellectual abilities, motivation or previous knowledge. The quality of classroom instruction, teachers' assessment practices, availability of instructional materials and the broader school leadership environment can also shape students' learning experiences. Omeodu (2019), for example, demonstrated the importance of instructional strategies in students' Physics achievement, while Adeoye (2020) established the relevance of systematic assessment of instruction to students' knowledge of Physics concepts. These observations suggest that improving Physics achievement requires attention to the wider instructional environment within which teaching and learning take place.

One important school-level factor that may influence the quality of instruction is principals' instructional leadership. Instructional leadership refers to the actions through which school principals provide direction and support for teaching and learning, supervise classroom

instruction, coordinate curriculum implementation, monitor students' academic progress and facilitate teachers' professional development. Hallinger (2011) explains that instructional leadership places the core activities of teaching and learning at the centre of school leadership, while Robinson, Lloyd, and Rowe (2008) found that leadership practices directly focused on instruction tend to have stronger relationships with student outcomes than leadership activities that are predominantly administrative. This implies that the principal's role extends beyond routine school administration to creating an environment in which effective classroom instruction can flourish.

The relevance of instructional leadership may be particularly pronounced in Physics because effective teaching of the subject often requires appropriate supervision, professional support, instructional resources and opportunities for teachers to improve their pedagogical practices. A principal who regularly monitors classroom instruction, provides constructive feedback, encourages collaborative professional learning and facilitates access to relevant instructional materials may create conditions that support effective Physics teaching. Leithwood, Harris, and Hopkins (2020) argue that successful school leadership is strongly connected to the improvement of teaching and learning conditions. Therefore, principals who prioritize instructional improvement may indirectly contribute to students' academic achievement by strengthening the professional environment in which Physics teachers work.

The second factor of interest is teachers' assessment literacy. Assessment literacy encompasses teachers' knowledge, skills and dispositions required to design, select, administer, interpret and appropriately use assessment information. Assessment is no longer viewed simply as a mechanism for assigning grades at the end of instruction; rather, it is increasingly understood as an integral component of the

teaching and learning process. DeLuca et al. (2016) describe assessment literacy in terms of teachers' capacity to understand and use assessment processes effectively, while Black and Wiliam (2009) emphasize the role of formative assessment in generating evidence that can be used to improve learning. Teachers who possess adequate assessment literacy are therefore better positioned to determine what students understand, identify misconceptions and modify instruction in response to evidence of learning.

Assessment literacy is particularly important in Physics because students may arrive at correct answers through memorization without possessing a sound understanding of the physical principles involved. Physics teachers therefore need assessment approaches that examine conceptual understanding, application, reasoning, interpretation and problem-solving rather than relying exclusively on recall-based questions. Hattie and Timperley (2007) established the importance of feedback in improving learning, particularly when feedback provides useful information about the learner's current performance and the steps required for improvement. In Physics classrooms, competent use of assessment information can help teachers detect misconceptions and difficulties in mathematical reasoning before they become persistent barriers to learning.

The effective use of assessment also depends on the teacher's ability to connect assessment evidence with subsequent instructional decisions. A teacher may administer frequent tests and assignments without necessarily using the resulting information to improve teaching. Assessment literacy therefore involves more than knowledge of assessment techniques; it includes the ability to interpret students' responses, provide meaningful feedback and use assessment evidence to adjust instructional strategies. DeLuca et al. (2016) emphasize the importance of teachers' knowledge and competence in assessment, while Black and Wiliam (2009) demonstrate that formative

assessment becomes educationally valuable when evidence of learning is used to modify teaching and learning activities. This makes teachers' assessment literacy a potentially important predictor of students' achievement in Physics.

Another factor that has attracted increasing attention in contemporary education is the use of digital instructional resources. These resources include computer simulations, educational videos, animations, digital textbooks, virtual laboratories, interactive presentations, mobile applications, online learning platforms and other technology-supported materials. Digital resources can provide opportunities for learners to visualize abstract concepts and interact with representations of scientific phenomena that may be difficult to demonstrate using conventional instructional materials. UNESCO (2023) notes that technology can support access to learning materials facilitate interaction and provide new possibilities for teaching and learning when it is appropriately integrated into educational practice. For Physics education, this creates opportunities to make complex and dynamic phenomena more observable and comprehensible to learners.

Digital instructional resources are particularly relevant to Physics because many physical phenomena cannot be easily observed directly in the classroom. Computer simulations, for instance, can enable students to manipulate variables and observe changes in physical systems, while videos and animations can illustrate processes that occur too rapidly, too slowly, at microscopic levels, or under conditions that are difficult to reproduce in school laboratories (Rutten, van Joolingen, & van der Veen, 2012; de Jong, Linn, & Zacharia, 2013). Technology-enhanced Physics instruction has consequently received increasing attention as a means of improving students' conceptual understanding and academic performance, particularly where digital tools are integrated with appropriate pedagogical strategies rather than used merely as substitutes for conventional teaching (Zacharia, 2007;

Smetana & Bell, 2012). Recent studies in Nigerian secondary schools have reported encouraging possibilities for the use of computer-based and ICT-supported approaches in Physics instruction. For example, Mamuda et al. (2023) found that computer-based instructional strategies were associated with students' performance in Physics in senior secondary schools in Kebbi State, while Akanbi and Afolabi (2023) examined teachers' perceptions of integrating ICT facilities into the teaching of secondary-school Physics in Kwara State. The implication is that digital resources may provide valuable instructional support when they are carefully selected, appropriately used and aligned with curriculum objectives and students' learning needs.

However, the mere availability of digital instructional resources does not automatically result in improved student achievement. Their educational value depends on factors such as accessibility, relevance, curriculum alignment, teachers' ability to use them and the pedagogical purposes for which they are employed. UNESCO (2023) cautions that technology should serve clearly defined educational purposes rather than being treated as an end in itself. Similarly, the OECD (2023) reports that the relationship between digital technologies use and learning outcomes depend considerably on the nature and quality of technology use. Thus, the question for secondary school Physics education is not simply whether digital resources exist in schools, but whether they are accessible and meaningfully integrated into classroom instruction.

The three variables considered in the present study are interconnected rather than completely independent. Principals influence the instructional environment by establishing academic expectations, supervising classroom practices and supporting teachers' professional development. Teachers, in turn, determine how assessment information is generated and used to guide instruction, while digital instructional resources provide additional tools for presenting concepts,

facilitating interaction and supporting assessment. Robinson et al. (2008) emphasize the instructional dimension of effective school leadership, while DeLuca et al. (2016) highlight teachers' assessment competence as an important component of effective assessment practice. The interaction among these factors suggests that students' achievement may be better understood through an integrated model that considers leadership, assessment and instructional resources simultaneously.

This integrated perspective is particularly relevant to Physics because effective teaching requires coordination between curriculum objectives, instructional strategies, assessment processes and learning resources. A principal may provide strong instructional supervision, but the impact of such leadership may be limited if teachers lack adequate assessment competence or if appropriate instructional resources are unavailable. Similarly, teachers may possess strong assessment literacy but face difficulties implementing effective Physics instruction where the school environment provides inadequate support and limited instructional resources. Effective educational practice therefore requires complementary contributions from school leadership, teachers and instructional resources. The issue is especially important in secondary school system, where national educational policy places substantial emphasis on science, technology and the development of learners' competencies for national development. The National Policy on Education identifies science and technology as important components of the education system and emphasizes the development of knowledge and skills necessary for technological advancement (Federal Republic of Nigeria, 2013). However, the successful realization of these policy intentions depends largely on what occurs within schools and classrooms. The gap between curriculum expectations and classroom realities makes it necessary to investigate factors that can strengthen

the quality of teaching and improve students' academic achievement in Physics.

The relationship between Physics and Mathematics further increases the educational significance of the present investigation. Mathematics provides the quantitative language through which many Physics concepts are expressed, represented and solved. Students' ability to manipulate equations, interpret graphs, reason proportionally, perform calculations and understand mathematical relationships can therefore influence their success in Physics (Kaldaras & Wieman, 2023). At the same time, Physics provides authentic contexts in which mathematical concepts can be applied to real-world phenomena, thereby enabling learners to connect abstract mathematical representations with observable scientific processes (Donnelly-Hermosillo et al., 2020). This reciprocal relationship means that improvements in Physics teaching may have implications beyond Physics achievement and may provide useful insights for strengthening Mathematics curriculum implementation.

Digital instructional resources can potentially strengthen the relationship between Physics and Mathematics by enabling students to visualize mathematical relationships within physical phenomena. Graphing applications, computer simulations, virtual laboratories and interactive models can allow learners to manipulate variables and observe corresponding changes in graphs, measurements and physical outcomes. Research on graphing technologies in K–12 science and mathematics education indicates that such technologies can support students in generating predictions, collecting and analysing data, interpreting relationships and investigating changes in phenomena such as kinematics and thermodynamics (Donnelly-Hermosillo et al., 2020). Similarly, computer simulations in Physics can provide interactive representations through which learners explore physical relationships and develop conceptual understanding, particularly

when the simulations are integrated with active learning approaches (Banda & Nzabahimana, 2021). Such experiences can help bridge the gap between abstract mathematical representations and their practical applications by encouraging students to connect mathematical expressions, graphical representations and physical phenomena. More specifically, recent work on blended mathematics–science sensemaking emphasizes the importance of expressing scientific concepts mathematically and coordinating mathematical and scientific reasoning when students investigate physical phenomena (Kaldaras & Wieman, 2023). Therefore, the integration of appropriate digital resources into Physics instruction may provide opportunities for Mathematics curriculum developers and teachers to design more contextualized learning experiences that connect mathematical reasoning with scientific applications.

Despite the growing literature on instructional leadership, assessment and educational technology, there remains a need for studies that examine their combined predictive contribution to students' achievement in Physics. Previous studies have often focused on individual instructional strategies, leadership behaviours, assessment practices or technology-supported learning. For instance, research has established the relevance of leadership for student outcomes (Robinson et al., 2008), formative assessment for learning (Black & Wiliam, 2009), teachers' assessment literacy (DeLuca et al., 2016) and educational technology for teaching and learning (UNESCO, 2023). However, comparatively less attention has been given to how principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics within the secondary school level.

This gap is important because contemporary educational improvement increasingly requires attention to the interaction between leadership, teacher competence and instructional resources. A

school may possess modern digital resources without achieving meaningful learning outcomes if teachers are unable to integrate them effectively. Likewise, teachers with strong assessment literacy may find it difficult to translate assessment evidence into improved learning where instructional leadership and school support are inadequate. The present study therefore provides an opportunity to examine whether these factors, considered individually and collectively, can explain meaningful variations in students' academic achievement in Physics. The present study consequently seeks to predict students' academic achievement in Physics through principals' instructional leadership, teachers' assessment literacy and digital instructional resources in secondary schools.

Purpose Of The Study

The main purpose of the study is to determine the predictive power of principals' instructional leadership, teachers' assessment literacy and digital instructional resources on students' academic achievement in Physics in secondary schools in Enugu State. Specifically, the study sought to determine the:

1. extent to which principals' instructional leadership predicts students' academic achievement in Physics in secondary schools in Enugu State;
2. extent to which teachers' assessment literacy predicts students' academic achievement in Physics in secondary schools in Enugu State;
3. extent to which digital instructional resources predicts students' academic achievement in Physics in secondary schools in Enugu State;
4. extent to which principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics in secondary schools in Enugu State.

Research Questions

The following research questions guided the study:

1. To what extent does principals' instructional leadership predict students' academic achievement in Physics in secondary schools in Enugu State?
2. To what extent does teachers' assessment literacy predict students' academic achievement in Physics in secondary schools in Enugu State?
3. To what extent do digital instructional resources predict students' academic achievement in Physics in secondary schools in Enugu State?
4. To what extent do principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics in secondary schools in Enugu State?

Hypotheses

The following null hypotheses were formulated and tested at 0.05 level of significance:

H₀₁: Principals' instructional leadership does not significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

H₀₂: Teachers' assessment literacy does not significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

H₀₃: Digital instructional resources do not significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

H₀₄: Principals' instructional leadership, teachers' assessment literacy and digital instructional resources do not jointly significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

Methods And Materials

The study adopted a predictive correlational research design. The design was considered appropriate because the study sought to determine the extent to which principals' instructional

leadership, teachers' assessment literacy and digital instructional resources predict students' academic achievement in Physics without manipulating any of the variables. Predictive correlational research is suitable for examining the relationship between naturally occurring variables and determining the extent to which one or more predictor variables can statistically explain variation in a criterion variable. In this study, principals' instructional leadership, teachers' assessment literacy and digital instructional resources constituted the predictor variables, while students' academic achievement in Physics constituted the criterion variable.

The study was conducted in secondary schools in Enugu State, Nigeria. Enugu State is located in the South-East geopolitical zone of Nigeria and has 304 public secondary schools providing education at the senior secondary level. The population of the study comprised 12,329 Senior Secondary School II (SS II) Physics students in public secondary schools in Enugu State in 2025/2026 academic session. SS II students were selected because they had sufficient exposure to major concepts in the secondary school Physics curriculum and were not yet primarily engaged in the external examination activities characteristic of SS III. A sample size of 391 SS II Physics students in Enugu State was used for the study. A multistage sampling procedure was used to draw the participants for the study. At first stage, simple random sampling technique was used to sample three education zones out of the six education zones in the state. At second stage, stratified proportionate random sampling technique was used to sample schools from the three education zones sampled.

Four instruments were used for data collection. They comprised students' version of: Principals' Instructional Leadership Questionnaire (PILQ), Teachers' Assessment Literacy Questionnaire (TALQ), Digital Instructional Resources Questionnaire (DIRQ) and Physics Achievement Test (PAT). The Students' Version of the Principals' Instructional Leadership Questionnaire

(PILQ) was developed by the researchers through literature review to obtain students' perceptions of the instructional leadership practices of principals in secondary schools. The instrument was designed based on the understanding that principals play an important role in creating and sustaining school conditions that support effective teaching and learning. The questionnaire therefore focuses on leadership practices that are observable to students and that have the potential to influence the quality of instruction and students' academic experiences. The PILQ consists of 20 items designed to measure students' perceptions of principals' involvement in promoting effective teaching and learning in their schools. The questionnaire was structured on a four-point rating scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD), with corresponding weights of 4, 3, 2 and 1, respectively. Students are expected to indicate the response that best represents their perception of the instructional leadership practices of their school principal.

The Students' Version of the Teachers' Assessment Literacy Questionnaire (TALQ) was also developed by the researcher to obtain students' perceptions of the assessment literacy of their Physics teachers. The instrument was designed to measure the extent to which teachers demonstrate appropriate knowledge, skills and practices in assessing students' learning. Since students are directly involved in classroom assessment activities, their perceptions provide useful information about how teachers apply assessment principles and practices during teaching and learning. The TALQ consists of 20 items that seek to determine students' perceptions of their teachers' knowledge, skills and practices in assessing their learning. The questionnaire was structured on a four-point rating scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD), weighted 4, 3, 2 and 1, respectively. Students are expected to indicate the response that

best represents their perception of the assessment practices of their Physics teachers.

The Students' Version of the Digital Instructional Resources Questionnaire (DIRQ) was also developed by the researchers to obtain students' perceptions of the availability, accessibility and utilization of digital instructional resources by their Physics teachers during teaching and learning. The instrument was designed to assess the extent to which digital technologies and electronic instructional materials are incorporated into classroom instruction to facilitate students' understanding and learning of Physics concepts. The DIRQ consists of 20 items that seek to determine students' perceptions of their teachers' use of digital instructional resources such as computers, projectors, interactive displays, educational software, digital simulations, multimedia materials, online learning platforms, digital videos and internet-based instructional materials. The questionnaire is structured on a four-point rating scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD), weighted 4, 3, 2 and 1, respectively. Students are expected to indicate the response that best represents their experience of the use of digital instructional resources by their Physics teachers. Higher scores indicate a higher level of students' perception of the availability and effective utilization of digital instructional resources, whereas lower scores indicate a lower level of utilization.

The Physics Achievement Test (PAT) was developed by the researcher to measure students' academic achievement in Physics. The instrument was designed to assess the extent to which students have acquired the knowledge and understanding of Physics concepts covered in the senior secondary school curriculum. The PAT provides an objective measure of students' academic achievement. The PAT consists of 40 multiple-choice items based on the Physics topics taught within the period covered by the study. Each item has four response options, labeled A,

B, C and D, with only one option representing the correct answer. The items were developed to cover different levels of cognitive processes, including knowledge, comprehension, application and analysis, thereby providing adequate representation of the learning outcomes expected from students at the senior secondary school level. Each correctly answered item attracts two marks, while an incorrect or unanswered item attracts zero mark. The maximum obtainable score is therefore 80 marks. A table of specifications was used to guide the distribution of items across the content areas and cognitive levels. This was done to ensure adequate content coverage and to reduce the possibility of over-representation of particular topics or cognitive skills.

The instruments were subjected to face validation by three experts, each from Physics Education and Measurement and Evaluation units of Science Education Department and one from Educational Management unit of Educational Foundations, all from Faculty of Education, University of Nigeria, Nsukka. The experts were requested to examine the instruments in terms of the relevance of the items to the study variables, clarity of language, adequacy of coverage, appropriateness of the response options and suitability of the items for the target respondents. Their observations and recommendations were used to modify and refine the instruments before the final administration. In addition to the face validity, the PAT was subjected to content validity through a well-developed table of specifications. The reliability of the instruments was established through a pilot study involving 20 SS II Physics students who were not included in the main study, but shares characteristics with those under investigation. The internal consistency of the PILQ, TALQ and DIRQ was determined using Cronbach's alpha coefficient because the instruments employed multiple Likert-type items. The reliability coefficients of 0.82, 0.87 and 0.85 were obtained for PILQ, TALQ and DIRQ respectively. Meanwhile, the reliability of the PAT was

established using Kuder-Richardson 20 (KR-20), since the items of the instrument were dichotomously scored, and the reliability coefficient of 0.89 was obtained. The researchers obtained the necessary permission from the relevant educational authorities and the principals of the sampled schools before commencing data collection.

The researchers, with the assistance of three postgraduate students, administered the questionnaires (PILQ, TALQ and DIRQ) to the students offering Physics in the sampled schools. One week after the administration of the questionnaire, PAT was also administered to the same set of students. The PAT was administered under controlled conditions to ensure that students completed the test independently. Completed instruments were checked for completeness before coding and analysis. Regression analysis was used in analyzing the data collected. Specifically, simple linear regression analysis was used to answer research questions 1, 2 and 3, while multiple regression analysis was used to answer research question 4. Meanwhile,

regression t-test was used to test hypotheses 3-5, while hypothesis 4 was tested using regression ANOVA. The regression results were reported using R , R^2 , adjusted R^2 , standard error of the estimate, F-statistic, regression coefficients (B), standardized beta coefficients (β), t-values and probability values. The coefficient of determination (R^2) was used to determine the proportion of variance in students' academic achievement in Physics explained by each predictor individually and by the three predictors jointly. All hypotheses were tested at the 0.05 level of significance. A null hypothesis was rejected where the associated p-value was less than 0.05 and retained where the p-value was greater than or equal to 0.05.

Results

Research Question One

To what extent does principals' instructional leadership predict students' academic achievement in Physics in secondary schools in Enugu State?

Table 1: Linear regression analysis of the extent to which principals' instructional leadership predict students' academic achievement in Physics in secondary schools in Enugu State

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.560 ^a	.313	.312	2.91882

(R^2) = Coefficient of Determination

The result presented in Table 1 shows that principals' instructional leadership has a moderate positive predictive relationship with students' academic achievement in Physics. The R value of .560 indicates a moderate positive relationship, while the R^2 value of .313 reveals that principals' instructional leadership accounts for 31.3% of the variance in students' academic achievement in Physics. The adjusted R^2 of .312 further indicates that 31.2% of the variance in students' achievement is explained by the predictor after adjustment. Thus, principals' instructional

leadership appears to make a meaningful contribution to students' achievement in Physics, although other variables not included in the model account for a substantial proportion of the unexplained variance.

Hypothesis One

Principals' instructional leadership does not significantly predict students' academic achievement in Physics in secondary schools in Enugu State

Table 2: Regression t-test analysis of significant predictive power of principals' instructional leadership on students' academic achievement in Physics in secondary schools in Enugu State

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1	(Constant)	24.865		21.645	.000
	PILQ	.366	.560	13.324	.000

The result in Table 2 indicates that principals' instructional leadership significantly predicts students' academic achievement in Physics in secondary schools in Enugu State. The standardized beta coefficient of .560 shows that principals' instructional leadership has a moderate positive predictive effect on students' achievement. The t-value of 13.324 with a significance value of .000, which is less than the .05 level of significance, indicates that the predictive effect is significant. Thus, the null

hypothesis was rejected, indicating that principals' instructional leadership significantly predicts students' academic achievement in Physics. This finding suggests that improvement in principals' instructional leadership practices is associated with improved students' achievement in Physics.

Research Question Two

To what extent does teachers' assessment literacy predict students' academic achievement in Physics in secondary schools in Enugu State?

Table 3: Linear regression analysis of the extent to which teachers' assessment literacy predict students' academic achievement in Physics in secondary schools in Enugu State

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.659 ^a	.434	.433	2.65000

(R²) = Coefficient of Determination

The result in Table 3 shows that teachers' assessment literacy has a moderately strong positive predictive relationship with students' academic achievement in Physics. The R value of .659 indicates a moderately strong positive relationship between teachers' assessment literacy and students' achievement, while the R² value of .434 reveals that teachers' assessment literacy accounts for 43.4% of the variance in students' academic achievement in Physics. The adjusted R² of .433 indicates that the predictor independently

accounts for approximately 43.3% of the variance in students' achievement. This suggests that teachers' assessment literacy makes a substantial contribution to explaining variations in students' academic achievement in Physics.

Hypothesis Two

Teachers' assessment literacy does not significantly predict students' academic achievement in Physics in secondary schools in Enugu State

Table 4: Regression t-test analysis of significant predictive power of teachers' assessment literacy on students' academic achievement in Physics in secondary schools in Enugu State

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1	(Constant)	22.925		22.920	.000
	TALQ	.449	.659	17.272	.000

The result in Table 4 shows that teachers' assessment literacy significantly predicts students' academic achievement in Physics in secondary schools in Enugu State. The standardized beta coefficient of .659 indicates a moderately strong positive predictive effect, suggesting that higher levels of teachers' assessment literacy are associated with higher levels of students' achievement in Physics. The t-value of 17.272 and significance value of .000, which is less than the .05 level of significance, indicate that the predictive effect is statistically significant. Thus,

the null hypothesis was rejected, indicating that teachers' assessment literacy significantly predicts students' academic achievement in Physics. This finding suggests that teachers who possess stronger assessment knowledge and skills are more likely to contribute to improved academic achievement among their Physics students.

Research Question Three

To what extent do digital instructional resources predict students' academic achievement in Physics in secondary schools in Enugu State?

Table 5: Linear regression analysis of the extent to which digital instructional resources predict students' academic achievement in Physics in secondary schools in Enugu State

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.524 ^a	.275	.273	2.99962

(R²) = Coefficient of Determination

The result in Table 5 shows that digital instructional resources have a moderate positive predictive relationship with students' academic achievement in Physics. The R value of .524 indicates a moderate positive relationship between digital instructional resources and students' achievement, while the R² value of .275 reveals that digital instructional resources account for 27.5% of the variance in students' academic achievement in Physics. The adjusted R² of .273 further indicates that approximately 27.3% of the variance in students' achievement is explained by

the predictor after adjustment. This suggests that digital instructional resources make a meaningful contribution to explaining variations in students' academic achievement in Physics, although a considerable proportion of the variance is associated with other factors outside the model.

Hypothesis Three

Digital instructional resources do not significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

Table 6: Regression t-test analysis of significant predictive power of digital instructional resources on students' academic achievement in Physics in secondary schools in Enugu State

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
1	(Constant)	25.525		21.175	.000
	DIRQ	.372	.524	12.142	.000

Table 6 presents the regression t-test analysis of the predictive power of digital instructional resources on students' academic achievement in Physics in secondary schools in Enugu State. The result shows that digital instructional resources significantly predicted students' academic achievement in Physics ($B = 0.372$, $SE = 0.031$, $\beta = 0.524$, $t = 12.142$, $p < .001$). The standardized coefficient ($\beta = 0.524$) further indicates a moderate positive predictive contribution of digital instructional resources to students' achievement. Since the probability value was less than the .05 level of significance, the null hypothesis that digital instructional resources do

not significantly predict students' academic achievement in Physics was rejected. Thus, the finding demonstrates that digital instructional resources constitute a significant predictor of students' academic achievement in Physics in secondary schools in Enugu State.

Research Question Four

To what extent do principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics in secondary schools in Enugu State?

Table 7: Multiple regression analysis of the extent to which principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics in secondary schools in Enugu State

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.822 ^a	.676	.673	2.01147

(R²) = Coefficient of Determination

The result in Table 7 indicates that principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly have a strong positive predictive relationship with students' academic achievement in Physics. The R value of .822 indicates a strong joint relationship between the three predictors and students' achievement. The R² value of .676 reveals that the three predictors jointly account for 67.6% of the variance in students' academic achievement in Physics, while the adjusted R² of .673 indicates that 67.3% of the variance remains explained after adjusting for the predictors included in the model.

This finding suggests that the combination of principals' instructional leadership, teachers' assessment literacy and digital instructional resources provides a substantial explanation of variations in students' academic achievement in Physics.

Hypothesis Four

Principals' instructional leadership, teachers' assessment literacy and digital instructional resources do not jointly significantly predict students' academic achievement in Physics in secondary schools in Enugu State.

Table 8: Regression ANOVA of significant joint predictive power of principals' instructional leadership, teachers' assessment literacy and digital instructional resources on students' academic achievement in Physics in secondary schools in Enugu State

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	3260.819	3	1086.940	268.645	.000 ^b
	Residual	1565.807	387	4.046		
	Total	4826.626	390			

The result in Table 8 shows that the regression model was statistically significant, $F(3, 387) = 268.645$, $p < .001$. This indicates that principals' instructional leadership, teachers' assessment literacy and digital instructional resources, when considered jointly, significantly predicted students' academic achievement in Physics. The regression sum of squares (3260.819) was substantially greater than the residual sum of squares (1565.807), indicating that the three predictors collectively accounted for a considerable proportion of the variation in students' achievement. Since the significance value was less than the .05 level of significance, the null hypothesis that principals' instructional leadership, teachers' assessment literacy and digital instructional resources do not jointly significantly predict students' academic achievement in Physics was rejected. The finding therefore suggests that the combined contribution of effective instructional leadership, teachers' assessment literacy and the availability and utilization of digital instructional resources is a significant predictor of students' academic achievement in Physics in secondary schools in Enugu State.

Discussion Of Findings

Extent to which principals' instructional leadership predicts students' academic achievement in Physics in secondary schools in Enugu State

The findings of the study revealed that principals' instructional leadership significantly predicted students' academic achievement in Physics. The

result showed a moderate positive predictive relationship with principals' instructional leadership accounting for 31.3% of the variance in students' academic achievement. The regression coefficient was significant, indicating that higher levels of principals' instructional leadership were associated with higher students' achievement in Physics. The finding suggests that principals, who actively communicate academic expectations, monitor classroom instruction, support teachers, supervise teaching and learning, promote professional development and provide an environment conducive to learning may create conditions that enhance students' achievement in Physics. The finding is particularly important because Physics requires effective coordination of curriculum implementation, practical activities, instructional resources and continuous monitoring of students' learning progress. The finding may be further explained by the nature of Physics as a subject that requires effective instructional planning, practical experiences, appropriate instructional materials, continuous assessment and opportunities for students to engage with abstract scientific concepts. A principal who prioritizes instructional supervision can encourage Physics teachers to adopt appropriate teaching strategies, utilize available laboratory and digital resources, monitor students' progress and provide remedial support where necessary. Therefore, instructional leadership may influence students' achievement not simply through direct contact with students but through the improvement of the instructional conditions and teacher practices within the school.

The finding is consistent with Robinson, Lloyd, and Rowe (2008), whose meta-analysis of 27 studies found that instructional leadership had a stronger relationship with student outcomes than transformational leadership. They identified goal setting, strategic resourcing, coordination and evaluation of teaching and the curriculum, teacher professional development, and the provision of an orderly and supportive learning environment as important leadership practices associated with student outcomes. These practices provide plausible explanations for the present finding because principals who concentrate their leadership activities on teaching and learning can influence the conditions under which Physics teachers plan lessons, use instructional resources, assess students and respond to learning difficulties. The finding also agrees with the broader evidence reported by Wu and Shen (2022), whose multivariate meta-meta-analysis of 12 previous meta-analyses found a statistically significant positive relationship between principal leadership and student achievement. Their finding further suggests that the influence of principal leadership can vary according to educational context and the particular leadership practices examined. The 31.3% variance explained in the present study therefore represents a substantial contribution within the context of secondary-school Physics, although it should not be interpreted as indicating that principals' instructional leadership is the sole determinant of achievement.

The result is also supported by the findings of Bada, Ariffin, and Nordin (2024) who reported that principals' instructional leadership practices, particularly defining the school mission, managing instructional programmes and developing a positive school learning climate, were significantly and positively associated with teachers' effectiveness in Nigerian secondary schools. Effective teachers are central to students' classroom learning, and therefore principals' capacity to strengthen instructional practices may

indirectly contribute to students' academic achievement. Similarly, Uwakwe (2017), in a study of secondary schools in South-East Nigeria, reported that principals' instructional leadership capacity positively influenced students' academic performance. This convergence with the present finding suggests that instructional leadership is relevant to secondary school students' achievement.

Extent to which teachers' assessment literacy predicts students' academic achievement in Physics in secondary schools in Enugu State

The study found that teachers' assessment literacy significantly predicted students' academic achievement in Physics. The result indicated a moderately strong positive predictive relationship with teachers' assessment literacy explaining 43.4% of the variance in students' achievement. The predictive contribution was statistically significant, suggesting that improvements in teachers' assessment literacy were associated with improved academic achievement among students. The moderately strong positive predictive relationship and the 43.4% variance explained suggest that teachers' assessment literacy made a substantial contribution to differences in students' achievement in Physics. This finding may be attributed to the fact that assessment-literate teachers are better positioned to identify students' learning difficulties, determine whether instructional objectives have been achieved, provide appropriate feedback and modify their teaching in response to students' needs. In Physics, where students are expected to understand concepts, solve quantitative problems, interpret graphs and apply principles to unfamiliar situations, effective assessment can provide teachers with evidence about the specific aspects of learning that require further instructional attention.

The finding is consistent with recent empirical evidence on formative assessment and student achievement. Yao et al. (2024), in a meta-analysis

of 118 studies involving 258 effect sizes, found that formative assessment had a positive effect on K–12 students' academic achievement, with the effects observed across different subject domains, including science and mathematics. The authors further reported that the effect was particularly meaningful when assessment was integrated into the teaching and learning process rather than treated as a separate activity. This supports the present finding because teachers with stronger assessment literacy are more likely to integrate assessment into instruction and use assessment information to guide subsequent teaching. The finding also agrees with the findings of Wisniewski, Zierer, and Hattie (2020), in a meta-analysis of 435 studies involving more than 61,000 learners, reported a medium overall effect of feedback on student learning, although the magnitude of the effect depended considerably on the quality and information content of the feedback. This provides an important explanation for the present result: assessment becomes more educationally valuable when teachers possess the knowledge and skills required to interpret students' performance and provide feedback that helps learners understand their errors and improve subsequent performance. The result is further supported by the findings of Adeoye (2020) found that systematic assessment integrated into Physics instruction had a significant effect on students' acquisition of Physics concepts at the knowledge level. The study suggests that continuous and systematic assessment can provide opportunities for teachers to monitor students' understanding during instruction rather than relying exclusively on end-of-course examinations. This is particularly relevant to the present finding because assessment-literate Physics teachers can use classroom assessment evidence to identify misconceptions and provide timely corrective instruction before such difficulties become established.

Extent to which digital instructional resources predicts students' academic achievement in Physics in secondary schools in Enugu State

The findings of the study revealed that digital instructional resources significantly predicted students' academic achievement in Physics. The result revealed a moderate positive predictive relationship with digital instructional resources accounting for 27.5% of the variance in students' achievement. The regression coefficient was significant, indicating that greater availability, accessibility and utilization of digital instructional resources were associated with higher academic achievement in Physics. The finding suggests that digital instructional resources made a meaningful contribution to students' achievement in Physics. This may be explained by the capacity of digital resources such as computer simulations, educational videos, multimedia presentations, virtual laboratories and interactive learning platforms to provide students with opportunities to visualize abstract concepts, manipulate variables, observe relationships and engage actively with Physics content. Such opportunities are particularly relevant to Physics because many concepts and phenomena cannot be readily observed or reproduced under ordinary classroom conditions.

The finding may also be explained by the ability of digital resources to complement rather than merely replace conventional instructional methods. When teachers integrate simulations, animations, videos, virtual experiments and other digital resources with explanations, questioning, practical activities and assessment, students can move between theoretical explanations and visual or interactive representations of the same phenomenon. This is particularly useful for difficult Physics topics involving motion, electricity, waves, fields and other phenomena that may be difficult to demonstrate adequately with conventional classroom materials. Evidence from a recent meta-analysis also indicates that combining real and virtual experiments can have

positive effects on learning achievement in Physics, particularly when teaching complex and abstract concepts.

The finding agrees with Banda and Nzabahimana (2021), who reviewed 31 quasi-experimental and experimental studies on the integration of Physics Education Technology (PhET) simulations and reported robust evidence that simulations can enhance students' conceptual understanding of Physics. The authors further noted that simulations can be incorporated into active-learning environments to create more meaningful learning experiences. This evidence provides support for the present finding because digital instructional resources can enable learners to interact with representations of physical phenomena and receive immediate visual feedback, thereby facilitating conceptual understanding and application of Physics principles. The finding is also consistent with Banda et al. (2022), whose study of PhET simulation-based learning among Physics students found significant improvement in students' achievement and reported that the technology supported students' visualization, understanding and conceptualization of Physics concepts. The authors associated the use of simulations with active learning, confidence and scientific thinking. These features may explain why students who learn Physics with appropriately selected digital resources can achieve better learning outcomes than those whose exposure is predominantly limited to conventional representations of abstract concepts.

The present result further agrees with evidence from Nigeria. Mamuda, Usman, and Yage (2023) examined computer-based instructional strategies among senior secondary school Physics students in Jega Local Government Area of Kebbi State. Their study investigated computer-based concept-mapping strategies and demonstrated the relevance of computer-supported approaches to Physics instruction. The finding is relevant to the present study because it provides evidence from

the Nigerian secondary-school context that computer-based instructional approaches have a place in Physics teaching and learning.

Extent to which principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly predict students' academic achievement in Physics in secondary schools in Enugu State

The findings revealed that the three predictors jointly made a significant contribution to the prediction of students' academic achievement in Physics. The multiple regression analysis produced a strong positive relationship with principals' instructional leadership, teachers' assessment literacy and digital instructional resources jointly explaining 67.6% of the variance in students' academic achievement. The overall regression model was significant. Thus, the combined influence of the three educational factors provides substantial predictive power for students' academic achievement in Physics in secondary schools in Enugu State. The strong positive relationship and the 67.6% variance explained by the three predictors demonstrate substantial predictive power. This suggests that effective instructional leadership may create the organizational conditions for quality teaching, teachers' assessment literacy may ensure that students' learning is systematically monitored and supported, while digital instructional resources may provide additional opportunities for students to visualize, explore and engage with difficult Physics concepts. The combined contribution of these factors therefore presents a more comprehensive explanation of students' academic achievement than consideration of any single predictor in isolation.

The joint predictive power may therefore be understood from a systems perspective. Principals establish the instructional direction and provide leadership support; teachers exercise professional knowledge in assessing students and using assessment evidence; and digital resources provide

additional tools through which curriculum content can be represented and explored. When these elements operate together, they can reinforce one another and create a more supportive instructional environment for Physics learning. For example, a principal who prioritizes instructional improvement may encourage teachers to participate in professional development, provide access to digital resources and monitor their instructional use. An assessment-literate teacher can then use digital tools to assess students' understanding, identify areas of difficulty and provide targeted feedback. Such interconnected practices may explain why the combined model accounted for a considerably larger proportion of achievement variance than any of the individual predictors.

The finding is consistent with the instructional leadership perspective advanced by Robinson, Lloyd, and Rowe (2008), who found through a meta-analysis that leadership practices directly focused on teaching and learning have a stronger relationship with student outcomes than leadership approaches that are less directly connected to instruction. Their findings emphasize practices such as coordinating and evaluating teaching, promoting teacher learning, setting academic goals and providing resources strategically. In the context of the present study, these leadership practices can provide the institutional support necessary for Physics teachers to strengthen their assessment practices and make effective use of available digital instructional resources. Thus, principals' leadership may function as an enabling condition through which teacher competence and instructional resources are translated into improved learning experiences.

The substantial contribution of teachers' assessment literacy in the combined model is also supported by evidence that effective assessment is integral to the teaching-learning process. Yao et al. (2024), in a meta-analysis of formative assessment studies, reported positive effects of formative

assessment on K–12 students' learning outcomes. Assessment-literate teachers are better positioned to generate evidence of students' understanding, identify misconceptions, provide meaningful feedback and modify instruction based on students' learning needs. In Physics, where students may experience difficulties in conceptual understanding, mathematical reasoning and application of scientific principles, the ability to continuously assess and respond to learning gaps is particularly important. The present finding therefore suggests that assessment competence may complement instructional leadership by enabling teachers to convert classroom information about students' learning into appropriate instructional decisions.

The contribution of digital instructional resources to the joint prediction is likewise supported by research on technology-enhanced Physics learning. Banda and Nzabahimana (2021), in their review of studies on Physics Education Technology simulations, found evidence that simulation-based instruction can enhance students' conceptual understanding of Physics. Digital resources can provide visual and interactive representations of phenomena that may be difficult to observe directly in conventional classrooms. Donnelly-Hermosillo, Gerard, and Linn (2020) similarly reported that graph technologies can support students' ability to generate hypotheses, collect and analyze data, and interpret changes in science and mathematics contexts. The present finding extends this body of evidence by showing that digital instructional resources become particularly meaningful when considered alongside leadership and assessment rather than as an isolated technological intervention.

Conclusion

In conclusion, the study establishes that improving students' academic achievement in Physics requires attention not only to what occurs within the classroom, but also to the wider

instructional conditions created and sustained at the school level. The evidence suggests that effective instructional leadership, competent assessment practices and purposeful use of digital instructional resources are interconnected components of a supportive teaching and learning system. When these elements operate together, they provide a more favourable environment for students to understand abstract concepts, receive timely instructional support, monitor their learning progress and engage more meaningfully with Physics.

RECOMMENDATIONS

Based on the findings and conclusion of the study, the following recommendations are made:

1. Secondary school principals should strengthen instructional leadership practices by giving greater attention to the quality of classroom instruction, regular monitoring of teaching and learning, provision of instructional support and communication of clear academic expectations. Rather than focusing predominantly on administrative responsibilities, principals should assume a more active role in creating conditions that support effective curriculum implementation.
2. State education authorities and school management should organize regular professional development programmes to strengthen teachers' assessment literacy. Such programmes should emphasize the construction of valid assessment tasks, appropriate selection of assessment methods, interpretation of assessment results, provision of meaningful feedback and the use of assessment evidence to modify instruction. This would enable assessment to function as part of the learning process rather than merely as a means of assigning grades.
3. Government and relevant education agencies should improve the provision and maintenance of digital instructional resources in secondary schools. Attention should be given not only to supplying computers, projectors and internet facilities, but also to providing subject-specific resources such as Physics simulations, virtual laboratories, educational software, digital instructional videos and interactive learning platforms.
4. Principals should encourage Physics and Mathematics teachers to integrate digital resources purposefully into classroom instruction. The use of technology should be linked to specific curriculum objectives and learning difficulties rather than treated as an end in itself. Teachers should therefore be supported to select digital resources that facilitate visualization, experimentation, problem solving, conceptual understanding and active student participation.
5. Teacher education institutions and professional development providers should incorporate instructional leadership awareness, assessment literacy and digital pedagogical competence into programmes for both practising and prospective teachers. This would help teachers develop the complementary competencies required for effective implementation of contemporary Physics and Mathematics curricula.
6. Curriculum planners should strengthen the integration of assessment and digital technology within Physics and Mathematics curricula. Curriculum materials should provide practical guidance on how teachers can use formative assessment information and digital tools to diagnose students' difficulties, provide feedback, differentiate instruction and promote higher-order thinking.
7. Education authorities should adopt an integrated school-improvement approach in which principals, teachers and curriculum specialists work collaboratively. Interventions aimed at improving students' achievement should avoid treating leadership, assessment and digital resources as isolated issues. Coordinated programmes that address these three dimensions simultaneously are more likely to produce

sustainable improvements in curriculum implementation.

8. School authorities should establish mechanisms for monitoring the effective use of digital instructional resources and assessment practices. Such monitoring should focus on how resources and assessment information are contributing to teaching and learning rather than merely confirming their availability or frequency of use.

Implications for Mathematics Curriculum

The findings of this study have implications for the way the Mathematics curriculum is conceptualised, implemented and evaluated in secondary schools. Although the empirical focus was students' achievement in Physics, the underlying educational processes examined in the study are not peculiar to Physics. Mathematics, like Physics, involves abstract concepts, symbolic representations, logical reasoning, quantitative relationships and problem solving. However, the conditions that shape the quality of Physics learning also provide useful insights into the broader processes through which the Mathematics curriculum is enacted in schools.

The study implies that Mathematics curriculum implementation is a multidimensional process rather than a simple transmission of prescribed mathematical content. The curriculum may specify what students are expected to learn, but the extent to which those expectations are realised is influenced by the instructional environment within which learning occurs. Principals' instructional leadership therefore represents an important contextual dimension of curriculum implementation. From this perspective, curriculum effectiveness cannot be considered entirely separate from the leadership structures through which teaching, learning and instructional priorities are organised in schools.

The findings also imply a closer conceptual relationship between assessment and Mathematics

curriculum. Assessment is not merely an activity that follows instruction; it is part of the curriculum process through which evidence of students' understanding is generated and interpreted. In Mathematics, where students' errors often reveal underlying misconceptions, assessment literacy becomes particularly significant because the quality of assessment information influences how teachers understand students' learning. Thus, the curriculum should be viewed as encompassing not only mathematical content and instructional activities but also the processes through which learning is identified, interpreted and improved.

Another implication concerns the position of digital technology within the Mathematics curriculum. The findings suggest that digital instructional resources can be understood as part of the contemporary learning environment through which mathematical ideas are represented and explored. This is particularly relevant to concepts involving graphs, functions, geometry, statistics and dynamic relationships, where digital representations can provide forms of visualisation and manipulation that are difficult to achieve through static instructional materials alone. The implication is therefore a shift from viewing technology as an additional classroom resource to recognising its potential as a medium through which mathematical concepts can be experienced and constructed.

The findings further imply that the Mathematics curriculum should be understood as an interconnected system in which curriculum leadership, assessment and instructional resources interact with classroom learning. The relatively strong joint predictive relationship observed in the study indicates that students' academic outcomes are associated with a combination of instructional conditions rather than with a single educational variable. Applied to Mathematics, this suggests that curriculum effectiveness is better understood through the alignment of school leadership, assessment processes, instructional practices and

learning resources than through any one component considered in isolation.

There is also an implication for the expected outcomes of the Mathematics curriculum. Contemporary Mathematics education places increasing emphasis on conceptual understanding, mathematical reasoning, problem solving, communication and higher-order thinking rather than on the reproduction of procedures alone. The interaction of effective instructional leadership, meaningful assessment and digital learning environments provides a context within which these broader curriculum outcomes can be pursued. However, curriculum effectiveness should not be judged solely by students' ability to recall mathematical procedures, but also by the extent to which curriculum experiences support

deeper understanding and the application of mathematical knowledge.

Finally, the study implies that curriculum evaluation should extend beyond the question of whether prescribed Mathematics content has been covered. Evaluation of curriculum effectiveness needs to consider the conditions under which the curriculum is translated into actual learning experiences. In this sense, students' achievement becomes an outcome of the interaction between curriculum content and the instructional environment in which that content is implemented. The study therefore broadens the understanding of Mathematics curriculum effectiveness from a content-centred perspective to one that recognises leadership, assessment and digital learning conditions as important dimensions of curriculum enactment.

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